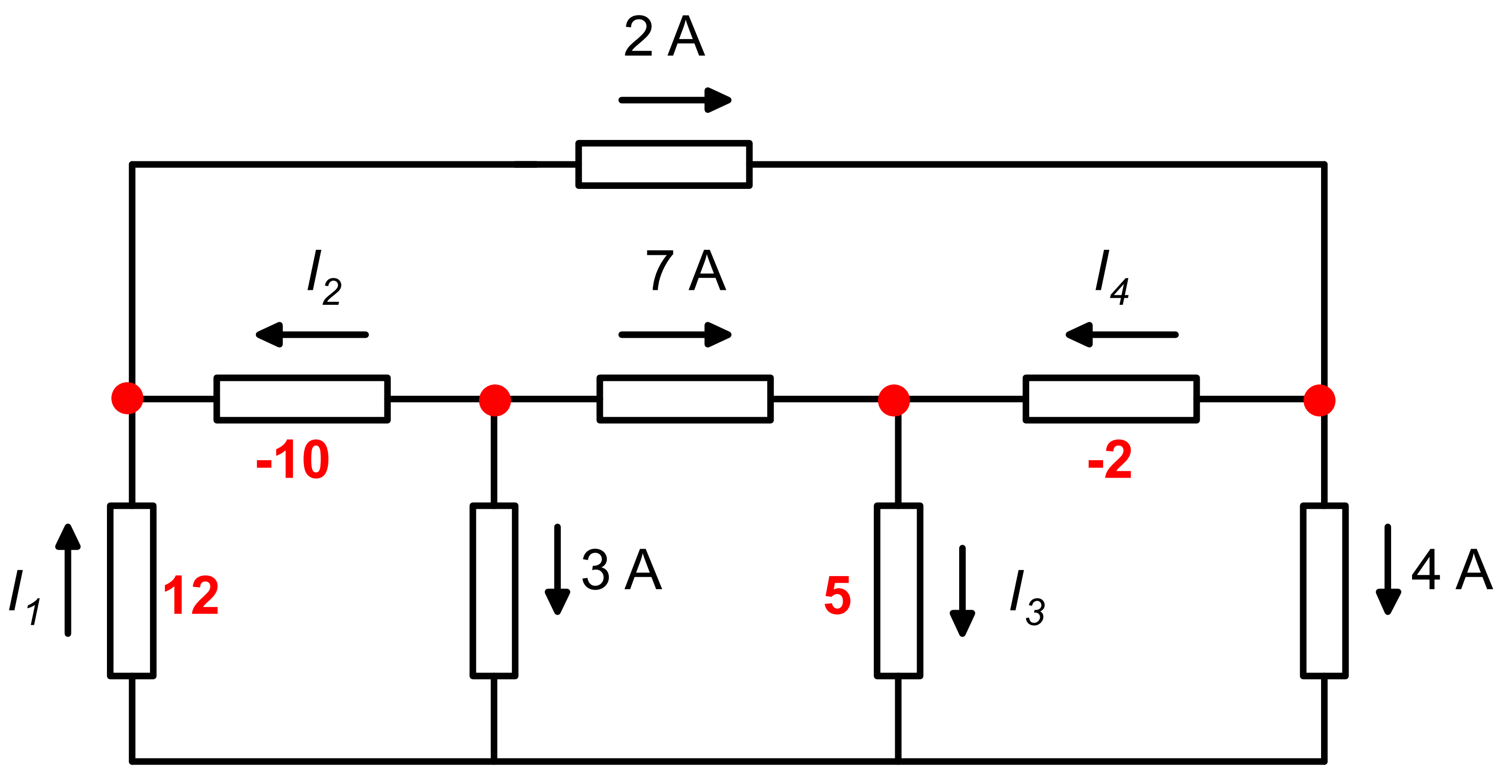
ESC201T : Introduction to Electronics

HW-1 : Solution

Q.1a Use KCL to find currents in the circuit shown below



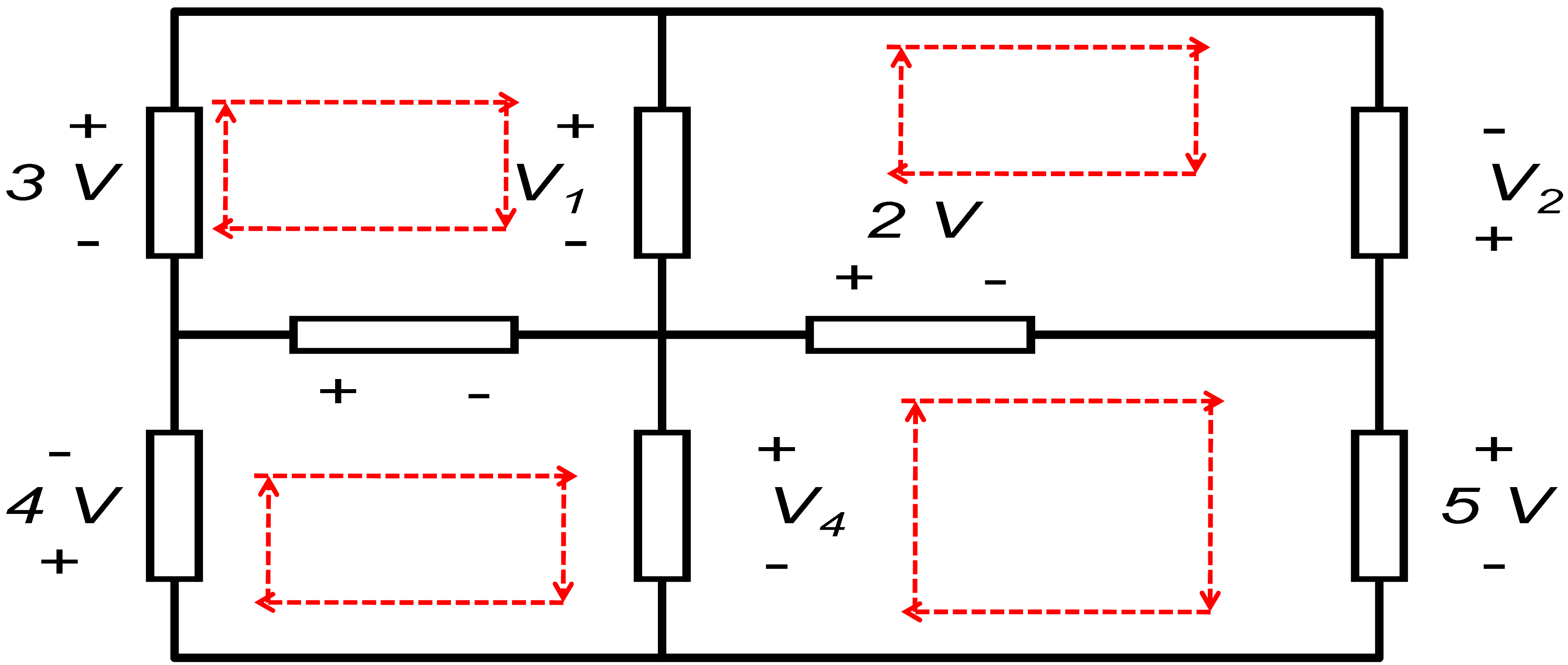
$$-7-3-i_2=0 \Rightarrow i_2=-10\ (3)$$

$$2-4-i_4=0 \Rightarrow i_4=-2A\ (1)$$

$$i_1+i_2-2=0 \Rightarrow i_1=12\ (4)$$

$$7+i_4-i_3=0 \Rightarrow i_3=5\ (2)$$

Q.1b Use KVL to determine all the voltages in the circuit shown below



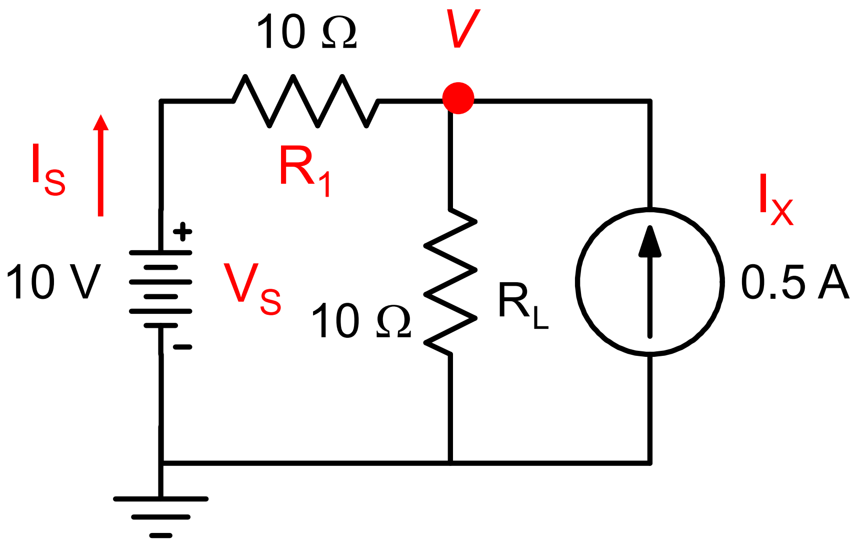
$$v_3 + v_4 + 4 = 0 \Rightarrow v_3 = -11V \quad (2)$$

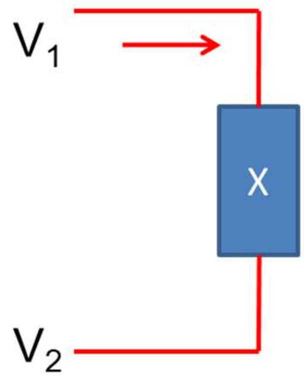
$$2 + 5 - v_4 = 0 \Rightarrow v_4 = 7V \quad (1)$$

$$v_1 - v_3 - 3 = 0 \Rightarrow v_1 = -8V \quad (3)$$

$$-v_2 - 2 - v_1 = 0 \Rightarrow v_2 = 6V \quad (4)$$

Q.2 Calculate the power supplied or absorbed by each element





$$P = (V_1 - V_2) \times I$$

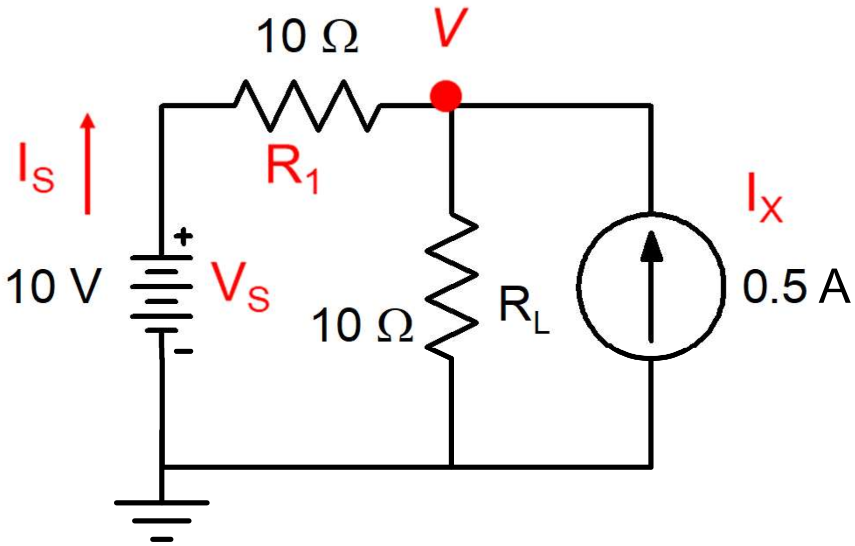
$$\frac{10 - V}{10} - \frac{V}{10} + 0 \cdot 5 = 0 \qquad \Rightarrow V = 7.5\, Volts$$

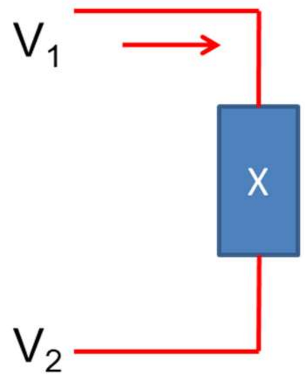
$$I_s = \frac{V_S - V}{R_1} = 0 \cdot 25A \qquad P_S = -I_S \times V_S = -2.5 \text{ W} \qquad P_X = -I_X \times V = -3.75 \text{ W}$$

$$P_1 = I_S^2 \times R_1 = 0.625 \text{ W} \qquad P_L = \frac{V^2}{R_L} = 5.625 \text{ W}$$

$$P_S + P_X + P_1 + P_L = 0$$

Q.3 Suggest one single change in the circuit above that would make the power dissipated in the load resistor (which is fixed at 10 ohms) four times larger





$$P = (V_1 - V_2) \times I$$

To make power 4 times larger, current through R_L has to be doubled which implies Voltage V has to be doubled

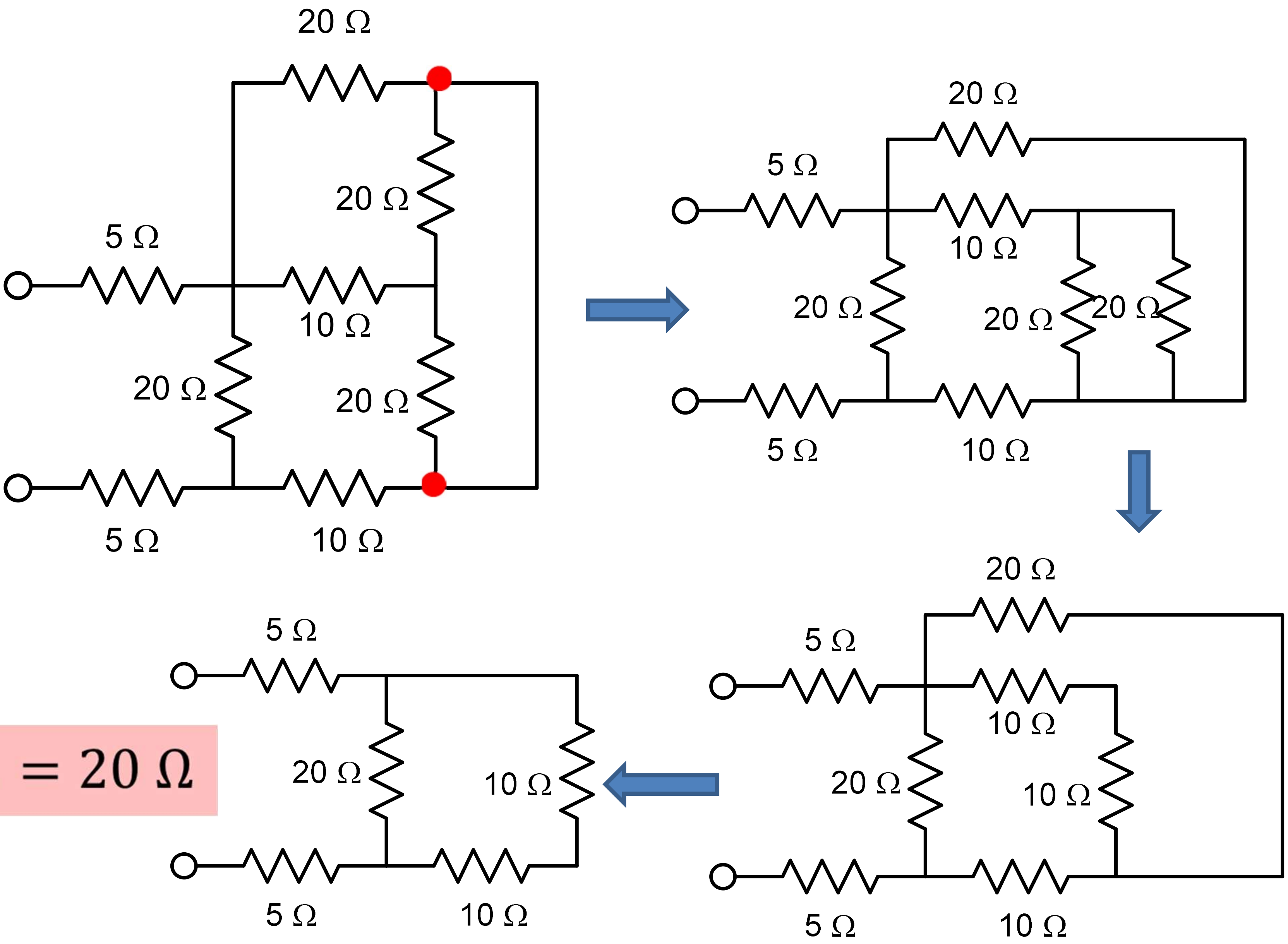
$$\frac{V_S - V}{R_1} - \frac{V}{10} + I_X = 0$$

$$V = \left(\frac{V_S}{R_1} + I_X\right) \times R_1 \parallel 10$$

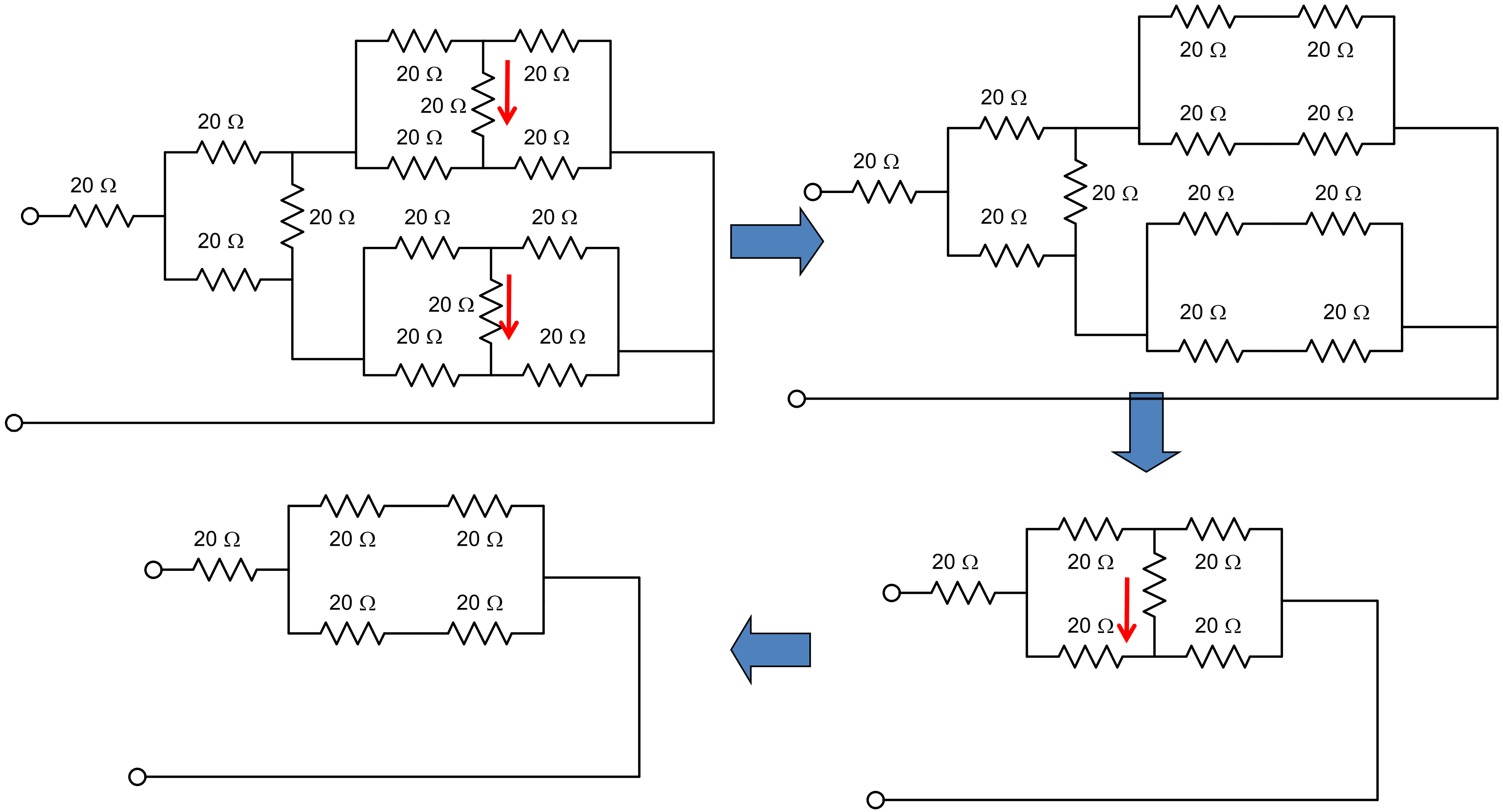
1+0.5

Increasing I_x to 2A will double the voltage and quadruple power

Q.4 Determine the equivalent resistance for the circuits shown below



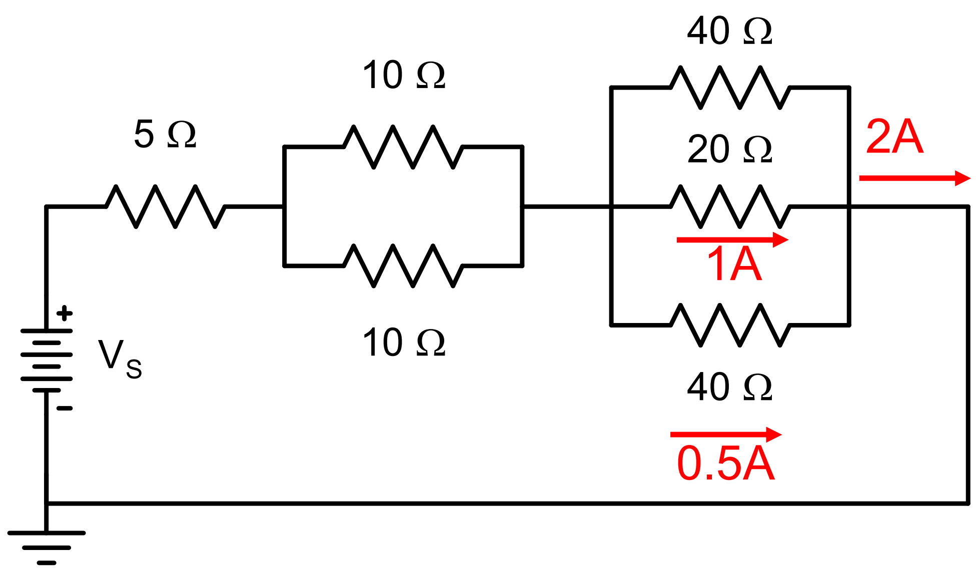
$$R_{eq} = 20\ \Omega$$



$$R_{eq} = 40\ \Omega$$

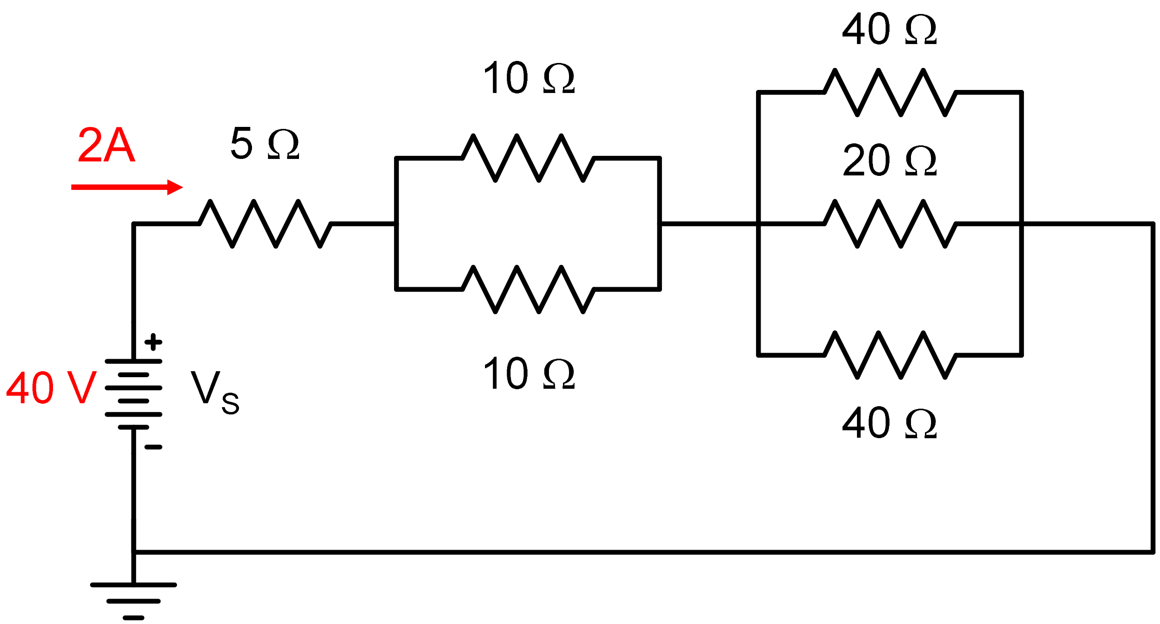
From symmetry we note that current in the indicated resistors will be zero which means that they can be open-circuited

Q.5 Determine the value of V_S such that current in the 20 ohms load resistor is 1A for the circuit shown below.



$V_S = 2 \times (5+5+10) = 40$ Volts

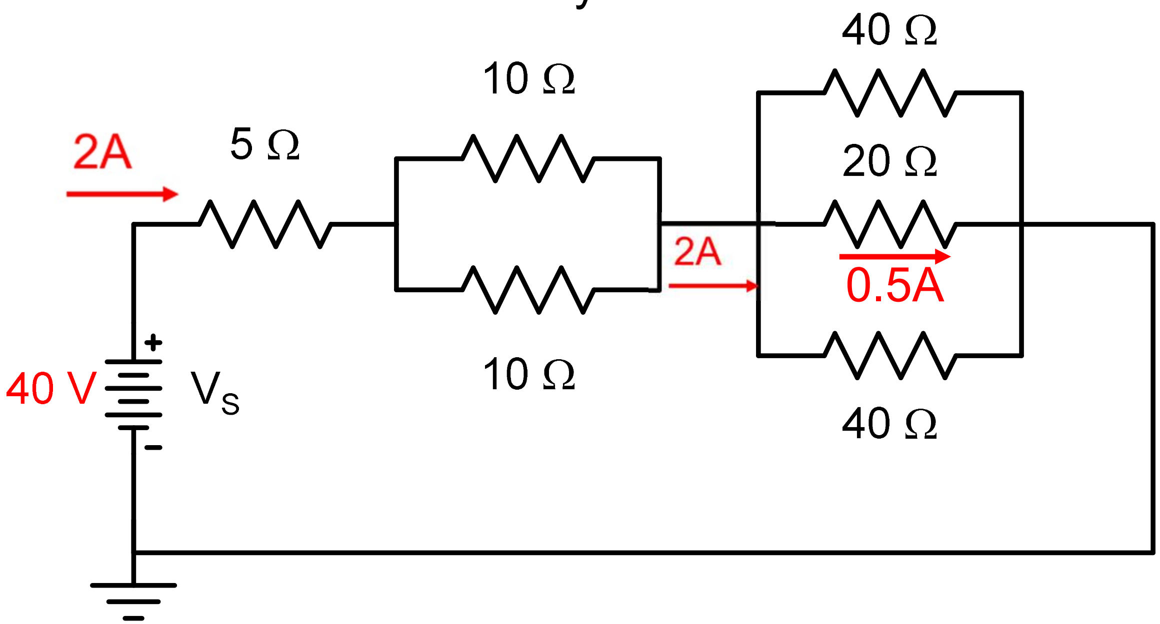
Q.6 For the value of V_S computed in Q4, suggest a change in one single resistor that would reduce the current flowing through 20 ohms resistor to 0.5A.



By reducing current through V_S from 2A to 1A, current through 20 ohms resistor would be halved

This can be done by doubling the net resistance seen by source V_S which is 5+5+10 = 20 ohms now. If we modify 5 ohms resistor to 25 ohms then this would be achieved.

Q.7 For the value of V_S computed in Q4, modify the resistance values in the circuit such that current through the 20 ohms resistor becomes 0.5A while maintaining the same current of 2A drawn from the battery as before.



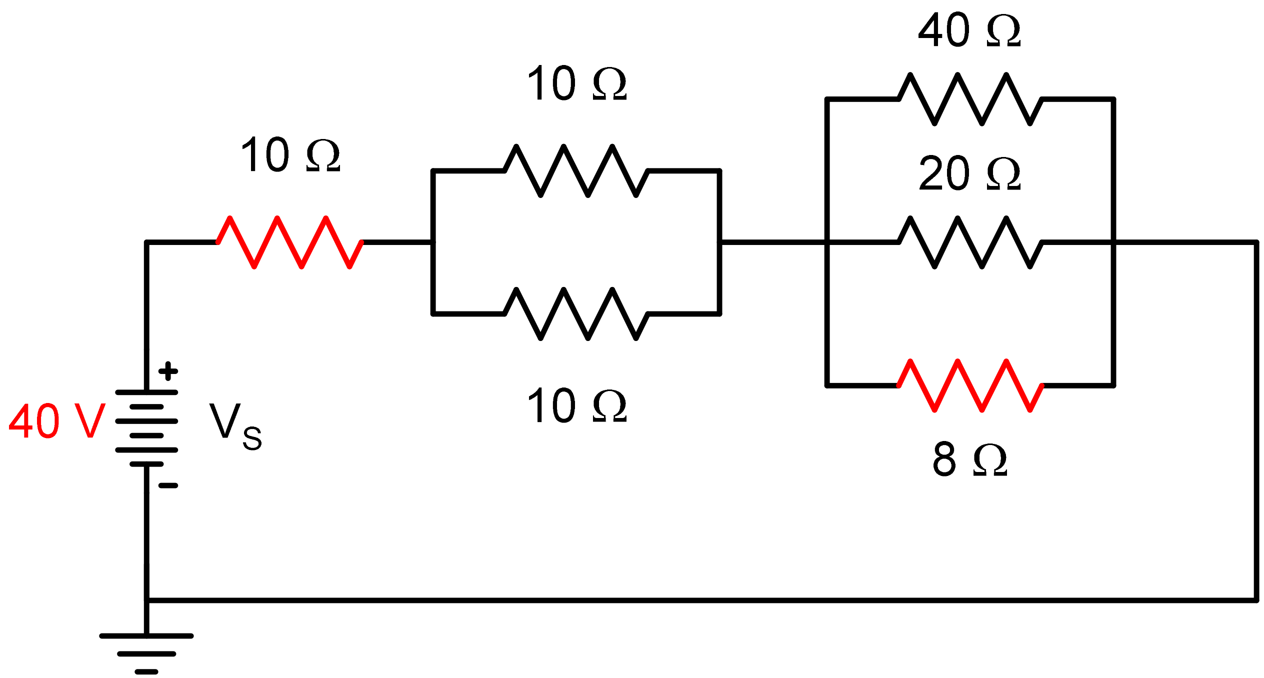
Let the parallel combination of two 40 ohms resistor be R_X

$$0.5 = 2 \times \frac{R_X}{R_X+20} \Rightarrow R_X = \frac{20}{3}\ \Omega \qquad \frac{3}{20} = \frac{1}{40} + \frac{1}{R} \Rightarrow R = 8\ \Omega$$

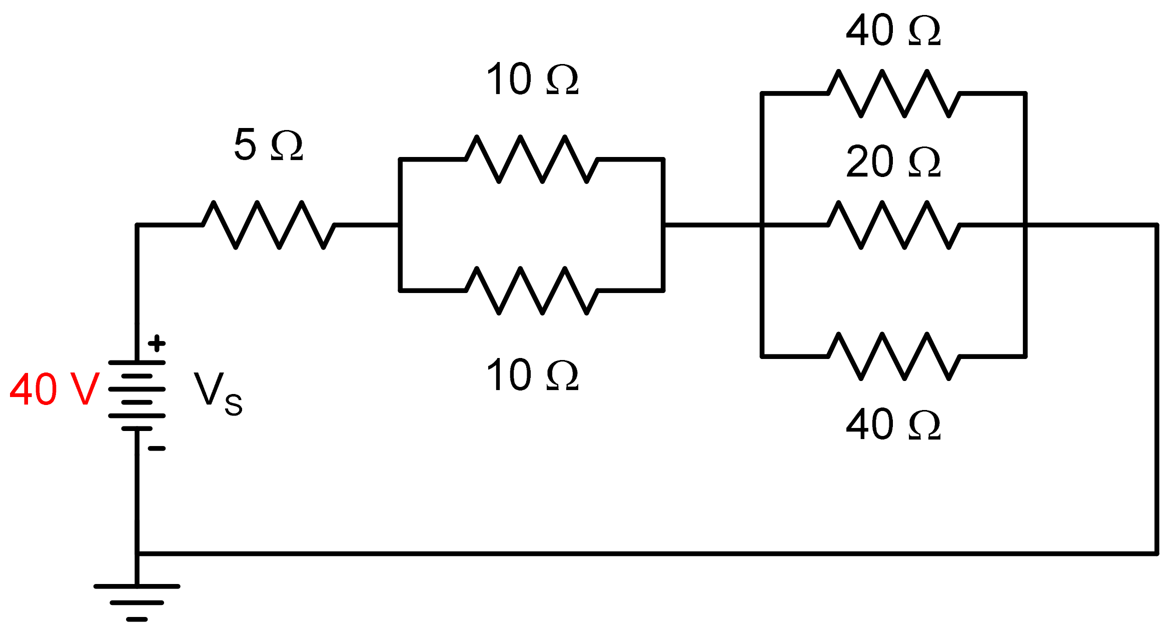
Change one 40 ohms resistor to 8 ohms.

Overall resistance drops to 5+5+ 5 =15 from a value of 20. So the five ohms resistor can be increased 10 ohms to restore net resistance

New Design



Q.8 For the value of V_S computed in Q4, determine the maximum and minimum values of the current flowing through the 20 ohms resistor if all resistors (except 20 ohms) have a tolerance of ± 5% (meaning their resistance can decrease or increase by 5% over their nominal stated values)



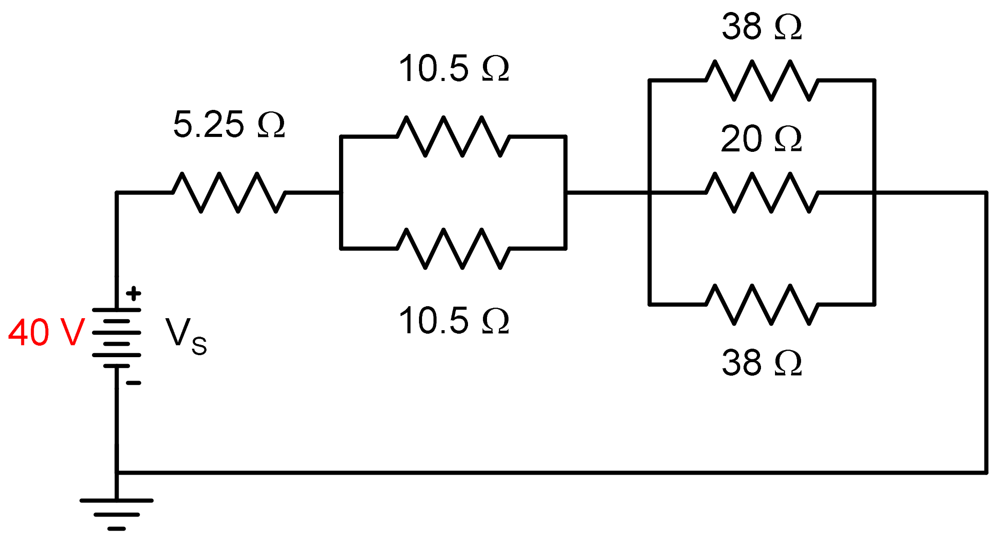
5 ohms can be maximum of 5.25 and minimum of 4.75 ohms

10 ohms can be maximum of 10.5 and minimum of 9.5 ohms

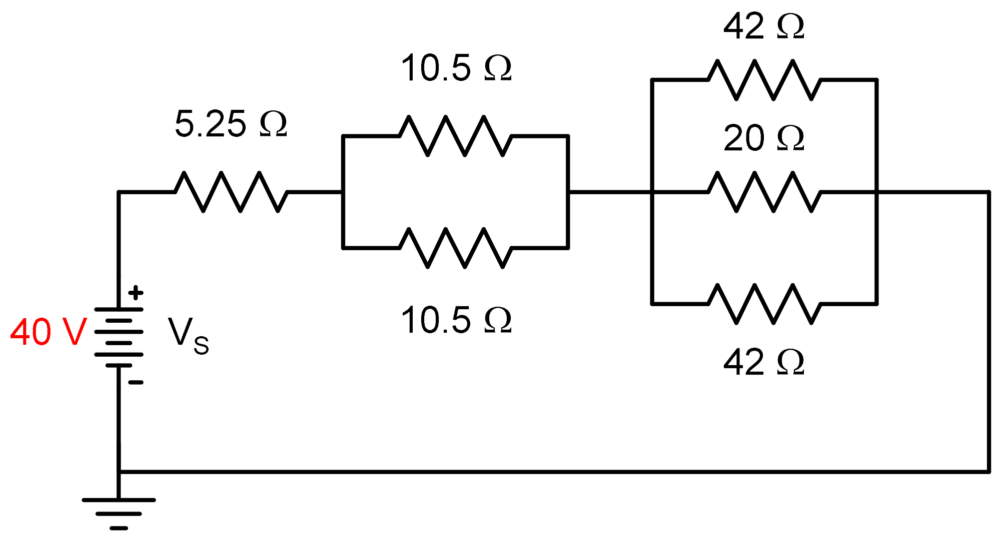
20 ohms can be maximum of 21 and minimum of 19 ohms

40 ohms can be maximum of 42 and minimum of 38 ohms

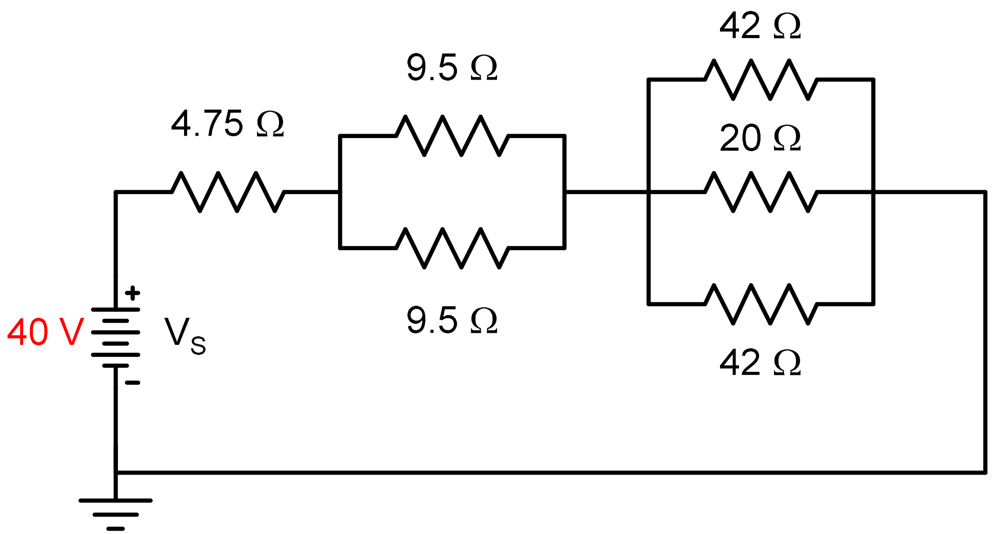
Minimum current of 0.962 A (3.8%) occurs under the condition:



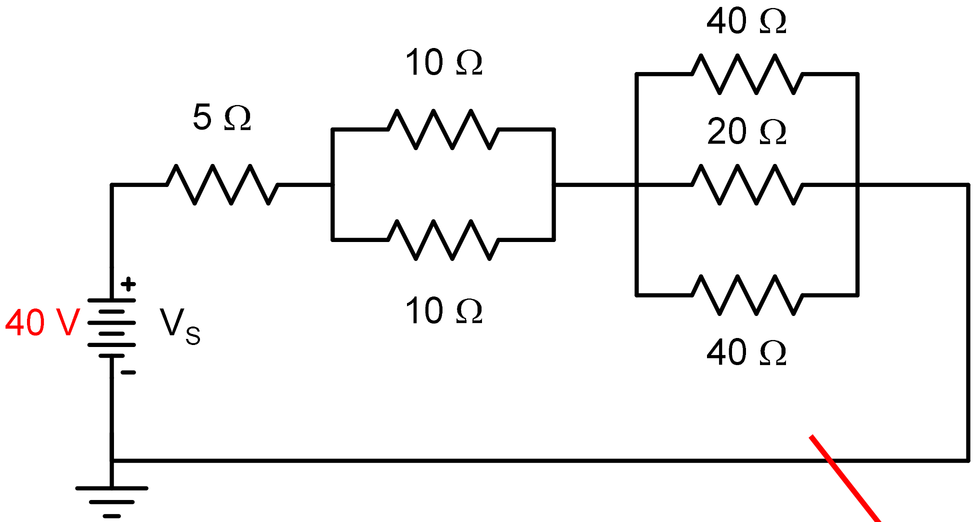
The following condition
gives a larger current of 0.987A

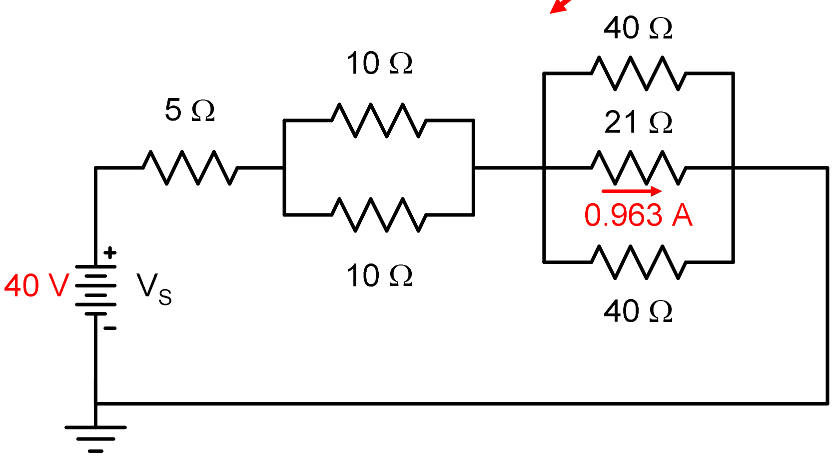


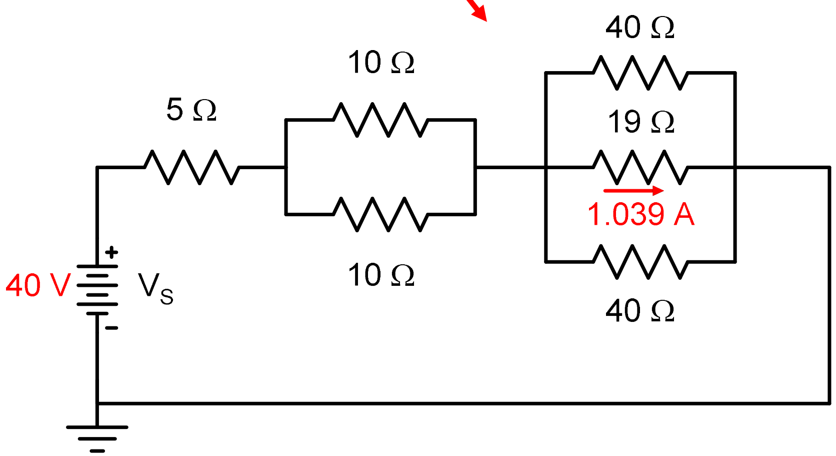
Maximum current of 1.038 A (3.8%) occurs under the condition:



Q.9 For the value of V_S determined in Q.4, determine the change in current flowing through the 20 ohms resistor if its value can change by ± 5% due to changes in temperature. All other resistors are constant.

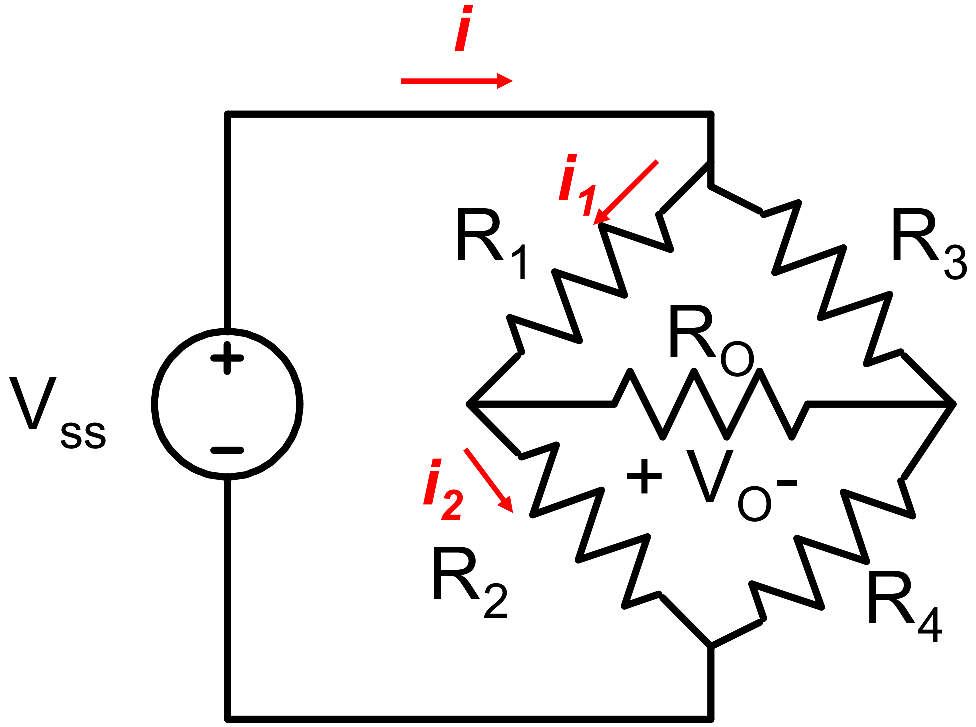






A maximum change of 3.9% occurs

Q.10 Determine the expression for the voltage Vo in the Wheatstone Bridge circuit shown below



$$-V_{SS} + i_1 R_1 + i_2 R_2 = 0$$

$$-V_{SS} + (i - i_1) R_3 + (i - i_2) R_4 = 0$$

$$i_1 R_1 + (i_1 - i_2) R_O - (i - i_1) R_3 = 0$$

$V_O =$

$$\frac{V_{SS} \times R_O \times (R_2 R_3 - R_1 R_4)}{R_2 R_4 R_0 + R_2 R_3 R_0 + R_1 R_4 R_0 + R_1 R_3 R_0 + R_2 R_3 R_4 + R_1 R_3 R_4 + R_1 R_2 R_4 + R_1 R_2 R_3}$$